

# **Electronic Commerce in the Electronics Manufacturing Industry**

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## Executive Summary

KPMG Consulting was engaged by NIST MEP to assist with the development of a generalized business case analysis for Electronic Commerce (EC) technology adoption within the electronics manufacturing supply chain. This business case is presented throughout this report in the form of EC adoption and maturity models, discussion of EC alternatives and industry adoption trends, and analysis of the electronics manufacturing supply chain. It is also presented in discussion of the various pressures that shape the supply chain.

KPMG was provided a draft outline and scope of the expected deliverable, which serves as the basis for this document's content. In accordance with the project scope, KPMG conducted secondary research into the electronics industry and into EC applications, developments and trends. KPMG then synthesized much of this secondary research, augmented it with observations by practicing EC consultants, and confirmed findings with members of the electronics industry's supply chain. This report was drafted in accordance with the outline. The limited budget for this effort necessitated a reliance on secondary information and personal observations only. It also limited the amount of professional time that KPMG could dedicate to this effort to approximately one week

To complete the project, KPMG formed an engagement team comprised of participants from three consulting practices: Electronic Commerce, Strategy and Technology, and Public Services Consulting. The KPMG team included a consultant with industry experience in supply chain EC initiatives for a leading microelectronics contract manufacturer. The team also included a KPMG manager performing strategic planning for EC adoption at some of the world's leading corporations, a senior manager experienced in market analysis of manufacturing technology adoption, and a consultant focused on EC process reengineering.

Consistent with the scope of this project, the research focus is on the electronics manufacturing industry (EMI) supply chain. Today the importance of the EMI is growing across a diverse set of industries including telecommunications, consumer electronics, transportation and health care. These industries, and many others, are increasingly dependent on technologically advanced products proliferating from the EMI.

Despite the industry's importance and size, it is only now enjoying significant growth in emerging markets such as Russia, Latin America and China.<sup>1</sup> The development of these diverse industry and geographic sectors as demand factors creates both advantages and challenges for all segments of the EMI supply chain. Diverse markets may create

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<sup>1</sup> Due to the limited time available for this project, only secondary information was available regarding these specific countries.

insulation against a traditionally cyclical business, but they also have different business and technical requirements.

The EMI can be viewed in five segments: (1) OEMs<sup>2</sup>, (2) electronic manufacturing service (EMS) providers and contract manufacturers (CMs)<sup>3</sup>, (3) component and semiconductor manufacturers, (4) distribution providers, and (5) service providers. Raw materials suppliers and other members of the supply chain are not included in this EMI definition. The EMI has followed a production life cycle similar to several other manufacturing sectors. First, operations are increasingly moving offshore to pursue cheaper labor costs. Second, divisions are segmented based on proximity tradeoffs between speed, costs and resident skill sets. And third, EMI OEMs are increasingly subcontracting non-core operations to key suppliers.<sup>4</sup> Intricate distribution networks and numerous service providers further increase this industry complexity. This environment of dispersed operations, supply chain lengthening and evolving industry roles necessitates technologies including EC to facilitate an exchange of information between disparate parties. EC applications such as EDI, the Internet and extranets are ideally suited to solve both fundamental and complex industry problems. When EC exchanges are ‘standard’ or ‘open’ across multiple parties in a supply chain, the power of information removes many complexities.<sup>5</sup>

The EMI is characterized by a race to streamline basic business processes to meet customers’ needs. These needs include requirements to shorten delivery times, reduce unit costs, and increase the pace of both product innovation and product development. To facilitate this effort, the design, development, production, and assembly of electronics products must be integrated wherever possible across the supply chain. Through the efficient use of EC, consumer and industrial electronics providers (OEMs) look for improved ways to exchange information. Such improved ways include electronic purchase orders, quotation requests, engineering change orders and forecasts to suppliers.

As the lines between industry participants blur, the need for EC to handle transactions, communications and other exchanges of information has increased. This industry participant “blurring” refers to an increased level of company interaction and a continued trend of suppliers assuming more of the roles traditionally held by customers (i.e., OEMs

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<sup>2</sup> For the purposes of this document, OEM refers exclusively to consumer and industrial electronics manufacturers.

<sup>3</sup> The term EMS will be used throughout this paper to reflect the increased scope of services typically provided by contract manufacturers.

<sup>4</sup> As illustrated in Exhibit 5 herein, OEMs are in fact outsourcing activities that could be considered core in addition to the non-core activities.

<sup>5</sup> Intricate distribution networks are one factor that may add to the complexity of the EMI. Although that complexity may not be entirely removed by standard EC exchanges, these exchanges may lower some of the traditional barriers associated with distribution. For example, distributors use EDI to let CMs know when a shipment has left their docks and CMs may use the Internet to view the status of their shipments.

passing responsibilities to EMS companies). The EMI is not unique in its need for widespread EC adoption, nor is it unique in the challenges it faces when integrating EC. It is however an industry that clearly benefits from increased EC adoption across the supply chain and it is an example for other industries to emulate because of its complex industry relationships, the technology that pervades its products and its already extensive use of EC technology. The business model for EC use is already being successfully demonstrated by high profile OEMs and less well known contract manufacturers and distributors in the EMI. Details of their models, and the challenges and opportunities presented by those models are explored in this report.

## **1.0 Overview of Electronic Commerce**

### **1.1 Electronic Commerce (EC) Background**

EC is a term used to describe the processes and mechanisms that organizations utilize to trade information electronically. It includes a group of technologies used to effectively communicate with customers or other companies to gather information or to conduct business transactions. EC utilizes information and telecommunications technology to support an exchange of information between companies. This exchange can effectively extend the value of electronic data interchange (EDI) to each aspect of doing business electronically throughout the supply chain. EDI, the Internet and e-mail are established ways of doing business for many companies as these technologies promote interoperability between organizations. Other common or emerging forms of EC include intranets, extranets and value added networks.<sup>6</sup> EC has evolved through the merging of telecommunications and computer networks to present opportunities for improved market access, reduced costs, optimized sourcing and increased revenue. These opportunities present challenges to the business models of practically every industry throughout the world.

Larger organizations within the EMI are typically more active in formalizing standards that provide consistency to business processes. This is often accomplished through industry organizations like the Electronics Industry Data Exchange Association (EIDX). Smaller EMI companies are subsequently encouraged to conform to these standards in order to effectively participate in the supply chain. The need to communicate in a consistent format with other organizations throughout the supply chain is becoming the norm in the EMI. Regardless of the need, the practice of communicating in a consistent format is only slowly becoming the industry norm. EMS providers and their suppliers are the driving force behind this practice, but because of the large number of players in the industry, the process is relatively slow. The need for a consistent format exists, and over time many smaller industry players will accept the need to conform and begin (or continue) to take steps to participate in the process. Although EDI has traditionally been one of the most common electronic commerce applications, companies that cannot afford integrated EDI systems face the possibility of losing a competitive advantage. In some cases, such companies may even be overlooked in favor of more technologically compliant organizations that offer more efficient means conducting business transactions.

Following are brief descriptions of practical EC technologies that are useful to the EMI. Some companies within the EMI supply chain are already extensively utilizing these technologies, but many smaller companies are not. This is significant due to the

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<sup>6</sup> Smart card technology is another widely used EC application, but is not relevant to this particular analysis of EC in the EMI.

preponderance of small companies in the industry supply chain and the constant fluctuations of industry roles within the EMI.<sup>7</sup>

### 1.1.1 The Internet

While contributions from other EC technologies are important, the TCP/IP protocol Internet is becoming the dominant EC tool. The Internet is successful because it is inexpensive, easy to use, highly accessible and it is becoming almost ubiquitous. The increase in its business-to-business transaction use is impressive given that it has been available for commercial use only since 1991. In fact, the Internet has seen the vast majority of its commercial acceptance and use during the past four years. Only two or three years ago companies were largely unsure that the Internet could play a significant role in business-to-business transactions.<sup>8</sup> Some companies believed that the Internet could potentially evolve into an advertising vehicle. Many companies expressed the notion that it would ultimately be no more than a novelty for industry. Today, industry analysts are predicting that Internet commerce in the U.S. alone will represent 2.3% of the GDP by 2002 and rise to 6% of the GDP by 2005.<sup>9</sup>

The Internet's utility for facilitating business-to-business transactions is easy to understand. The Internet enables companies to communicate with both customers and suppliers around the world. This communication helps companies learn more about customers, competitors and suppliers. Companies can display their products and services to all buyers possessing a connection to the World Wide Web. This display can range from simple advertising to sophisticated technical specifications and even pricing. The seller can update information cheaply and in real time enabling the Internet content to remain current. Companies can also gain access to new suppliers with whom they would otherwise not have contact. This contact can facilitate the optimization of sourcing and purchasing activities, which can yield reduced costs, improved terms, and better quality (however quality is defined by the participating entities). The Internet is increasingly successful in facilitating improved sales for many companies in numerous industries. In fact, some OEMs are recognizing substantial Internet sales that are accounting for a growing percentage of overall revenue.<sup>10</sup>

Internet sales fall into two broad transaction categories. First, the Internet is used as a marketing vehicle to promote eventual sales that are executed in a traditional channel. Such is the case where a business includes a catalog and price list on its Web site that

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<sup>7</sup> The dynamics of supplier relationships in the EMI are representative of even the most changing of industries. Relationships and roles have changed rapidly, outsourcing is widespread and supply chain challenges are growing. This is more fully explored in Section 2.0.

<sup>8</sup> This information is based on primary research conducted by KPMG and Telesis Corporation for NIST MEP at 163 small and mid-size manufacturers regarding technology adoption and performance improvement. Companies interviewed represented thirteen industries and a wide geographic distribution.

<sup>9</sup> Forrester Research Inc.

<sup>10</sup> Internet sales are strong at OEMs Cisco Systems, Dell Computer, Gateway Computer and many suppliers to the OEMs.

buyers use for comparison shopping before making a purchasing decision through a traditional channel. The second transaction category directly uses the Internet as the vehicle to facilitate the entire purchase. This includes marketing , bidding, negotiating and the actual sales transaction (including integration with back office systems). The process of reviewing specifications, completing design changes and addressing modifications is also enabled using this technology. This would be the case if in the previous example, the vendor's Web site could facilitate a secure transaction for the customer who enters the necessary ordering information directly on the Web site.

The Internet enables purchasers to determine the best prices for materials from a multitude of suppliers. At first this implies a departure from relationship selling and the traditional sales model. However, closer examination of the way companies are buying over the Internet reveals a possibility that this tool can actually enhance the relationship between buyer and seller. This may be accomplished where a supplier's output is already recognized for high quality and the supplier enjoys a good reputation in the marketplace. If the customer has already experienced the supplier's product and delivery of after sales service, then the Internet can become an information delivery mechanism regarding product features, customer testimonials, real time pricing, and ordering information that sustains the relationship. In this manner, a vendor's Web site can actually be used to handle repeat orders in a low-cost, very fast manner. Although relationships will not be based on Internet presence and use alone, the tool can be useful in supporting relationship elements like credit standards, quality standards, payment terms and conditions, and other elements of a successful business relationship. As companies in several industries continue their efforts to reduce supplier bases, more critical relationships will be formed between all members of the value chain that thrive by using the Internet.<sup>11</sup>

Internet content is always changing as companies attempt new approaches to delivering information, creating value and generating a critical mass of prospective buyers to their Web sites. Companies that go beyond using Web sites as simple marketing vehicles and use them to facilitate transactions (e.g., facilitate the review of specifications, design and engineering details; conduct bidding and negotiations; and consummate sales) will recognize a distinct advantage in linking to potential partners. Internet commerce innovation is high and the entry barriers are relatively low which helps drive innovation and experimentation. Traditional channels and methods of marketing, sales and distribution are now being challenged by the opportunity for direct access to upstream and downstream supply chain partners everywhere.

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<sup>11</sup> See Analysis and Observations for a more complete discussion on this trend in the EMI.



### 1.1.2 Electronic Data Interchange

Electronic data interchange (EDI) is another widely used EC tool. While it is not as ubiquitous as the Internet and it may cost more to utilize the tool, EDI has made tremendous contributions to EC and to business-to-business information exchange. EDI is the translation of business documentation into structured and standardized electronic messages for computer-to-computer communication between companies. The most commonly used EDI transaction sets tend to be purchase orders and commercial invoices which are electronically sent between companies that utilize the standardized forms for conducting business. In addition to simple business information translation, EDI also assists in the creation of strategic business partnerships and business processes for companies in any industry. EDI is currently widely used in the manufacturing (including EMI), retail and distribution sectors by members throughout the supply chains.

EDI differs from basic e-mail in that the messages can be interpreted by the receiving computers without human intervention. Additional benefits of incorporating EDI systems include cross-company or cross-industry standardization, transaction automation, the ability to handle large transaction volumes, and reduced operating costs due to improved inventory and production management. Regardless of the transaction sets used, benefits are realized when electronic transmissions of documents flow directly from customers' systems to trading partners' systems. For example, transmitting purchase order data directly from a customer to a vendor's order entry and accounts receivable systems reduces clerical oversight and purchase cycle time. These improvements ultimately reduce both errors and costs.

EDI has proliferated despite its relatively high cost and the fact that the implementation of standardized forms prohibits a direct linkage to every possible partner. Also, EDI is not useful in supporting every process throughout an organization. These facts have largely made EDI the purview of supply chains that are dependent on a relatively small group of very large customers such as the automobile industry.

One of the difficulties of effectively using EDI is that there are several versions of the technology. This can present problems for those companies that desire to communicate using EDI unless they maintain the resources and systems to adequately address this challenge. The challenge is not principally the number of translators required, but rather it is the challenge faced by companies to remain current with the latest versions and technologies. This is not unique to the EMI or to any single technology. Any technology or communication media offers similar challenges to adopting organizations.

It is important to recognize how partners must initially establish EDI exchanges. This requires an investment of both time and capital at the outset of a project to tailor an EDI transaction to meet each organization's needs. The high level processes for establishing a trading partner EDI exchange are as follows:

#### Initial Contact and Testing

- EMS provider makes initial contact with the supplier;
- EDI Trading Partner Agreement signed;
- EMS provider provides EDI mappings; and
- Testing of actual EDI transactions.

#### Implementation

- After completion of EDI testing, both parties are notified and the first official transaction is sent out and checked by users; and
- A "production pilot stage" using limited part numbers is usually recommended.

#### On-Going Analysis and Maintenance

At the outset, weekly conference calls or some other form of communication is held to ensure that the process is working smoothly and all of the appropriate people are involved from both organizations.

### 1.1.3 Value Added Networks

Value Added Networks (VANs) comprise another category of networks enabling companies to conduct EC. VANs differ from the networks described above in that they are not based on the Internet. VANs also differ in that they are maintained by private companies and are dedicated to EDI between those companies. Typically, larger companies have been the only ones with the resources and the requirements to establish and manage VANs. These were typically developed for divisions within a single company or they were developed to enable the exchange of information between members of a supply chain.

### 1.1.4 Intranets

Intranets are TCP/IP protocol networks that facilitate Internet-like communication within a closed user group such as a single corporation. Intranets are useful for companies managing decentralized operations, widely dispersed resources or disparate business units. An intranet may also facilitate a company's knowledge network or knowledge management system. These types of systems can provide employees with access to a central repository of useful company and market information. New programs such as sales campaigns, special promotions and changes in pricing policies can also be effectively communicated to the entire closed user group. These systems can greatly help employees

collaborate on projects, locate key internal resources, and disseminate explicit and even tacit information.

Regardless of the actual intranet use, the information that is accessed on these systems is usually business sensitive. Thus, intranets offer firewall protection of their databases to limit access only to authorized users in the closed user group.

#### 1.1.5 Extranets

Extranets are also TCP/IP protocol networks in which the intranets of two or more companies are shared in part or in total. These network-based applications utilize the power of the Internet to facilitate information sharing among a limited group of companies. Companies benefit from access to sources of information resident at other companies that are using the extranet. Extranets provide this exchange of information in a secure manner that protects each participating company's sensitive information from outside entities.

Some innovative companies in the EMI, particularly OEMs, are setting up multiple networks that are customized for key customers. These extranets provide customers with access to account data, purchasing information and technical write-ups germane to an individual customer. Another use for these networks is that they can share important information with customers regarding how others are using a seller's products. Such information can be carefully tailored to the unique needs of the target customer and can create a selling opportunity that would otherwise require a greater investment and a salesperson's efforts to convey.

The distinction between extranets and the Internet is that the former is open only to those companies with access to the network. Extranets are useful in allowing different companies to collaborate on projects, share design information, communicate sales forecasts and materials requirements, and plan projects. Essentially, extranets enable companies to capitalize on the benefits of the Internet, but do so with firewall protection that secures sensitive information from outside entities. Companies can gain several competitive advantages using extranets including the sharing of key business processes and systems with partners and creating closer relationships between members of a supply chain. Extranets can provide additional advantages for organizations that are required to work closely with outside business partners, suppliers and customers to get products to market or complete unique projects.

Extranets represent an evolution of EDI by providing the benefits of "virtual" integration throughout the supply chain. The idea behind virtual integration as used by some innovative computer makers to describe their own supply chain operation is to make the supply chain tighter and more responsive. This tightened supply chain is more flexible, better able to understand customer needs and has cross dependencies that far surpass traditional supply chains or vertically integrated companies.

Extranets combine the use of EDI with Internet technologies. This promotes the collaboration and communication necessary to facilitate the virtually integrated company described above. Companies are able to realize the benefits of multi-company computing as they did with EDI, but they can extend these benefits to a broader number of functional disciplines beyond the purchasing function. These additional opportunities include engineering, design, project management, scheduling, delivery and production. The use of extranets for facilitating closer ties with companies throughout supply chains is yielding completely new business models and opportunities for innovative companies.

Despite these opportunities, using extranet technology alone will not provide complete exchange between supply chain members. For example, EDI translation problems may still occur based on different EDI versions.

### **1.2 Overview of EC Adoption**

Companies adopt EC at different rates and with different scopes, but they generally follow a trend which is illustrated in Exhibit 1 below. This EC adoption model includes three stages of EC maturity: Experimentation, Ad-Hoc Implementation and Integration.

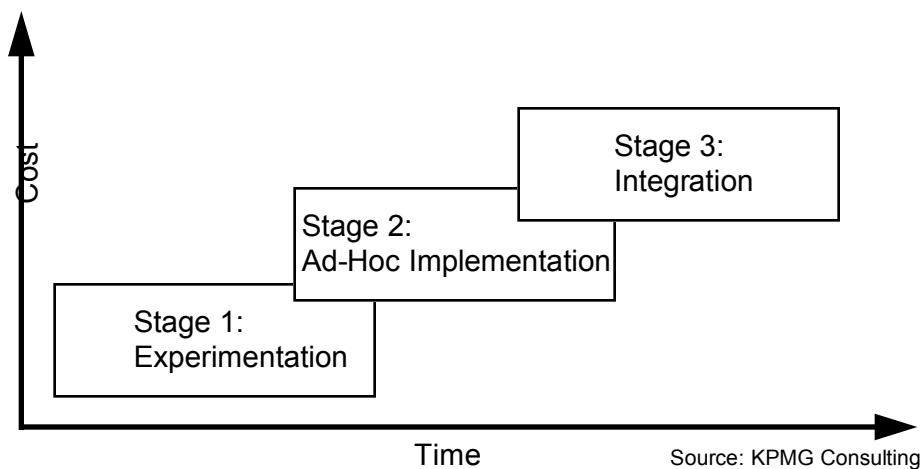


Exhibit 1: Stages of EC Maturity

In this model, Stage 1 is devoted to experimentation with various EC technologies. During this stage, companies may form internal groups to analyze technologies, specific applications, costs and potential impacts to the business. At this stage companies may also experiment with a specific technology in a confined setting, but they do not pursue full-scale implementation which may require board approval and extensive process redesign.

After companies experiment with EC technologies, they migrate to Stage 2 which is ad-hoc implementation. As in Stage 1, this does not typically involve board level approval

or a great deal of enterprise-wide process redesign. It may require limited investments in technology and the formation of a team to lead the narrow implementation and follow-up activities. It may also require the redesign of certain processes that are directly impacted by the prospective technology. Follow-up activities may involve analysis of initial results, discussions with customers regarding preferences and further study of EC trends. It is at the conclusion of this stage that the company must prepare a business case for going forward into Stage 3. An effective business case for this migration may include a cost-benefit analysis, an impact assessment, a summary of competitors' activities related to EC use, a presentation of the evolving business model, a summary of processes impacted by the technology and/or an evaluation of technology trends that support the implementation. Most companies that are interested in EC currently operate in Stages 1 or 2.

Before embarking on Stage 3, the company typically must secure board approval of the business case. The board will recognize from the business case that the effort may to require extensive process redesign, present both technical and cultural issues, and perhaps significantly impact the business model and strategy employed by the company. The board should also appreciate the fact that these challenges are costly and perhaps painful to address, but that the cost of not doing so may be a less effective business model than the competition.

With board approval the company will redesign processes as necessary, invest in the appropriate technology and make a commitment to a sound project management methodology. Stage 3 can be both time consuming and expensive. Depending upon the degree to which the company seeks to integrate EC, it can also be very disruptive. Clearly key processes must remain operational and existing marketing channels must remain robust throughout the integration effort.

Prior to embarking too far into Stage 3, the company needs to carefully consider the objectives of full-scale implementation and how these objectives comply with existing strategies. When migrating to this stage, companies cannot rely on the leadership or investment of a single division, but must have an enterprise-wide commitment and vision for the EC.

In reviewing the model above, it is evident that as projects move forward, the total investments rise. This fact, coupled with the need for board-level approval for the final stage, suggests that companies adopting EC should plan projects carefully to minimize total costs. They should also develop meaningful firm-specific information during the first two stages in order to support the business case for the board's investment decision.

It is important to recognize divisions or classes of EC adopters in the industry. Larger industry participants are generally the leaders in adopting the technology, while small and mid-sized players generally lag in EC adoption. The larger participants lead in EC

adoption for several reasons. These companies typically enjoy larger information technology departments, budgets, and capabilities; resources to participate in organizations like EIDX; greater technical staffs attracted by higher salaries; more time to plan, design and implement EDI systems; and a potentially greater requirement to interface with numerous trading partners. Those participants that lag in EC adoption typically have far fewer information technology resources to promote optimal adoption. Industry position, organizational size and resources may best characterize classes of industry EC adopters.

In addition to the Stages of Maturity model above, we recognize trends in the adoption of the Internet as a tool to facilitate EC. This integration exists in four broad phases: marketing, publishing, transaction and interactive as illustrated in Exhibit 2 below.

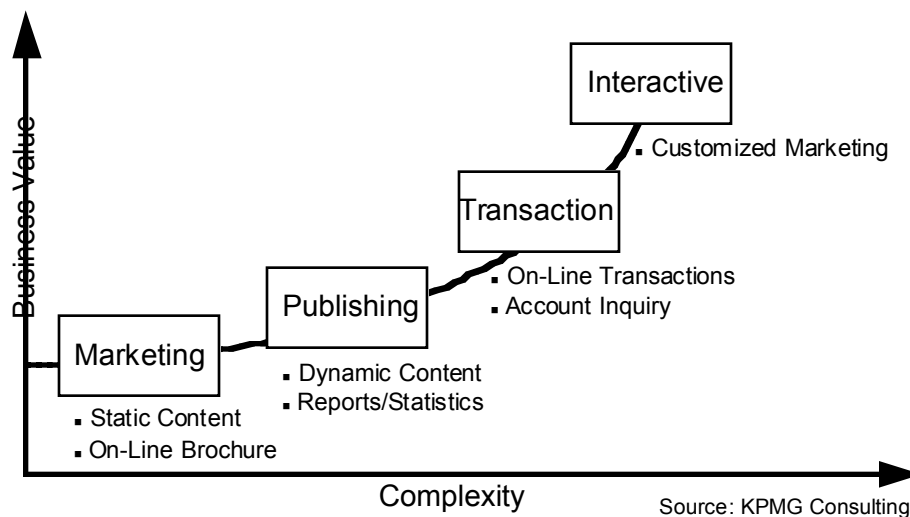


Exhibit 2: Adoption Model

During Phase 1 of the Adoption Model, companies limit activities to relatively low risk marketing efforts. The content of these efforts is an extension of traditional marketing information. Examples include basic company information, product descriptions and order forms for printout.

After experiencing Phase 1, companies typically pursue a second phase that includes publishing. The content of Phase 2 is updated on the Web site to move customers to self-directed customer service. Examples of published information include available inventory, pricing information, customer testimonials and industry news. During this phase, users may be required to identify themselves to access the information.

Phase 3 is focused on transactions. During this stage customers have the ability to place orders on-line. These are then either integrated into a single system or they are printed

out and manually entered into the process. Users at this stage are required identify themselves.

When companies are comfortable with the previous phases, they may decide to move into Phase 4. This is the interactive phase where customer orders are dynamically linked into the procurement process with multiple hooks. Status reports on specific orders are often available which help bring customers and suppliers closer than ever.

EC adoption by companies in all industries presents challenges in addition to opportunities. Challenges include both technical and non-technical issues that should be addressed prior to completing each of the phases described in the models above. While technical issues may appear to be the greater of the two categories, non-technical issues often are considered more difficult. Companies responding to KPMG electronic commerce surveys in 1996 and 1997 indicated that EC adoption is not perceived to be an entirely technical issue.<sup>12</sup> A comparison of these surveys reveals that companies increasingly believe successful EC implementation is predicated on properly redesigning business processes rather than simply overcoming technical challenges. In many cases the redesign of processes is extensive. Such is the case where the EC implementation results in a completely new business model and corresponding strategy. Responding companies indicated a declining concern over technical issues such as cost (40% in 1997, down from 46% in 1996) and security (32% in 1997, down from 39% in 1996). Respondents also indicated a greater interest in cultural issues such as internal resistance to new technology (50% in 1997, up from 44% in 1996). Fully 16% of the respondents identified including the Internet as part of their overall strategy as important.

Much of the EMI has been proactive in conducting business process redesign and associated process improvement. There has been a push to automate inventory replenishment using technology and business processes such as VMI (vendor managed inventory). Purchasing activities typically have not been passed to engineering, but there is a push to improve the efficiency of purchasing where practicable. What is critical is that companies must look at the business processes behind each of the technical issues. For example, when EMS providers form new partnerships with vendors, they often first map out the business process on both ends to understand exactly how the required information (purchase orders, invoices, engineering designs, etc.) will come through the channel (e.g., EDI). They also assess how this information will be handled on the other side. The significance of process mapping and redesign should not be overlooked.

To consider the simple example of a purchase order process, it is necessary to consider several factors. First, the frequency that the VAN is checked for incoming messages should be considered. Second, the responsibility for checking the VAN and

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<sup>12</sup> KPMG 1997 Electronic Commerce Research Report surveying 101 large companies in manufacturing , retail and wholesale distribution, financial services and other services.

communicating the information to the necessary parties should be assessed. Third, the processing of the information must be established. And fourth, the type of ERP system in place and the manner in which information is translated into the system should be considered.

This simple example demonstrates that it is not just the technical transfer of information that must be addressed, but also the underlying business processes. It is important to understand that improved processes facilitate more effective partnerships and promote efficiently information transfer.

An additional outcome of the research presented above is the conclusion that companies are concerned about the competitive threat that EC poses to their businesses. Companies' concern revolves around the threat of the Internet facilitating new market entrants (29% in 1997, up from 15% in 1996). Other threats described in the surveys include added complexity (36% in 1997, up from 27% in 1996) and increased competition (34% in 1997, up from 25% in 1996). Interestingly, 27% of the respondents believe that the Internet poses no threat whatsoever to their businesses. Responses to the same KPMG surveys regarding EC adoption indicate that companies are already polarizing into clear leaders and laggards. Fully 31% of the respondents believe that they are ahead of industry in adoption and 15% believe that they are falling behind.

The Internet was widely viewed as the most important EC tool for the future. KPMG survey respondents indicated that they most often use the Internet for gathering news and information (77%), performing market research (70%), and conducting marketing activities (69%). While not as common, transaction-based uses of the Internet were also reported which revealed a trend from 1996 to 1997. Responding companies indicated that 27% use the Internet for electronic ordering (up from 13% last year) and 22% use the Internet for electronic payment (up from 11% last year). Other commercial uses of the Internet include research related to supplier selection (35%), communication with existing suppliers (52%) and customer queries regarding sellers' inventory (13%). The Internet is expected to continue strong growth across most applications over the next three years.

These findings and trends indicate that EC is going to continue to grow and in many industries it will drastically alter business models. This growth is particularly predictable when looking exclusively at the Internet. Irrespective of the specific EC technology or its impact on business models, it appears that demand for business process redesign, strategic and technology planning, and systems integration will increase as companies pursue this new frontier.



## 2.0 EMI Industry Overview, Market Description and Trends

### 2.1 EMI Industry Structure and Demographics

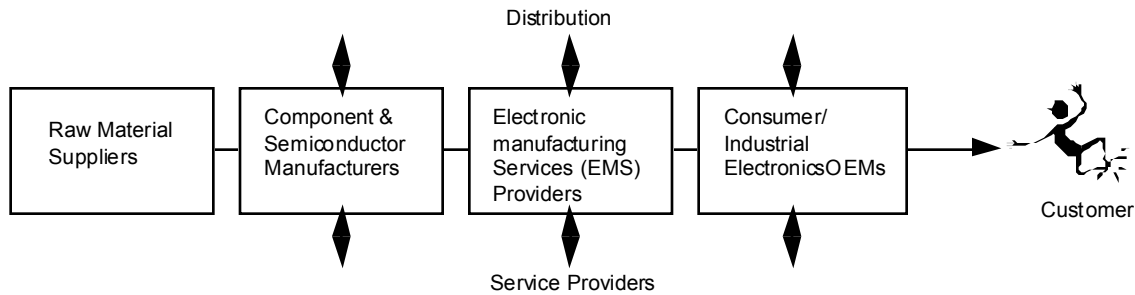


Exhibit 3: EMI Industry Structure<sup>13</sup>

The EMI supply chain can be segmented into raw materials suppliers, component and semiconductor suppliers and manufacturers, electronics manufacturing service (EMS) providers/board assemblers, and the consumer and industrial electronics manufacturers (OEMs). Within the supply chain there are also distributors and general service providers that service various segments of the industry.

What makes the EMI supply chain unique?

- Products consist of printed circuit boards populated with hundreds of small components per individual board. These components range from very expensive and complex microprocessors to commodities such as electronic capacitors, resistors and connectors.
- Competition (particularly in the commodities market) has spawned hundreds of suppliers per individual component. This makes vendor selection, procurement and logistics challenging. This has also spawned the growth of numerous “mom and pop” shops as industry suppliers.
- Due to the increasing pressure to reduce costs and offer value-added services, the EMI has gone through global expansions within each sector. This allows companies to take full advantage of the economies of scale provided by global operations.

<sup>13</sup> The critical role that board fabricators play in the industry should be noted. This role is critical to the supply chain and could be analyzed further in a larger study.

- There are constant market fluctuations in pricing and in demand -- especially for the EMI commodities market.
- Increasing competition in the EMI requires that companies form well organized and communicative supply chains. It is not uncommon to find smaller supply chains forming within the established larger supply chains.
- The fast paced nature of the electronics business demands that organizations develop new and innovative products to stay ahead of the competition. They must also search for ways of reducing the time required to introduce these new products into the marketplace.
- With the fast pace of product innovation in the EMI, companies must maintain manufacturing capabilities to meet demands. EC plays an important role in transferring the information of design changes to industry participants. OEMs routinely present last minute design changes to EMS providers. Those EMS providers that respond the fastest generally get the most business. An EMS provider can reduce its response time if it is capable of getting the necessary information into its systems faster. Although manufacturing entities may never respond fast enough by many OEM's standards, EC can play a critical role in facilitating response time reduction.

Clearly this is a unique industry with special requirements. The use of EC to meet these requirements is feasible and necessary from the OEMs' perspective and from the perspectives of each company along the supply chain. These companies need EC if they want to participate in the industry as it evolves in terms of higher quality, faster product development, continued just-in-time deliveries and a downward pressure on costs. Each of the segments of the value chain is discussed briefly below.<sup>14</sup>

### 2.1.1 Original Equipment Manufacturers

Original Equipment Manufacturers (OEMs) are referred to in this supply chain model as consumer and industrial electronics manufacturers. They are primarily responsible for printed circuit board (PCB) manufacturing and assembly, box build, and ultimately, completed systems for consumer use. They mainly consist of the major manufacturers of computer, network, telecommunications and industrial computer products.

Traditionally, OEMs have managed their own design, prototyping, purchasing, manufacturing, marketing and sales. However, the increasing costs of production, global competition, competitive pricing, and reduced time to market requirements have forced OEMs to outsource much of their production and logistics functions to electronic

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<sup>14</sup> Raw material suppliers are omitted from this analysis.

manufacturing service (EMS) providers and contract manufacturers. (See Exhibit 5 under EMS Service Providers below.)

In order to coordinate the outsourcing of work to suppliers and others, OEMs increasingly dependent on EC to provide the vehicle for communication throughout the supply chain. OEMs in the EMI encounter many of the same challenges that companies in other industries face. They also realize the same advantages. In the KPMG EC surveys mentioned above, there was widespread agreement on the advantages of adopting EC. With 41% of the respondents to these surveys representing large manufacturers, this provides us with a reasonable framework representing the opinions of OEMs in the EMI. Results are tabulated in Exhibit 4 below.

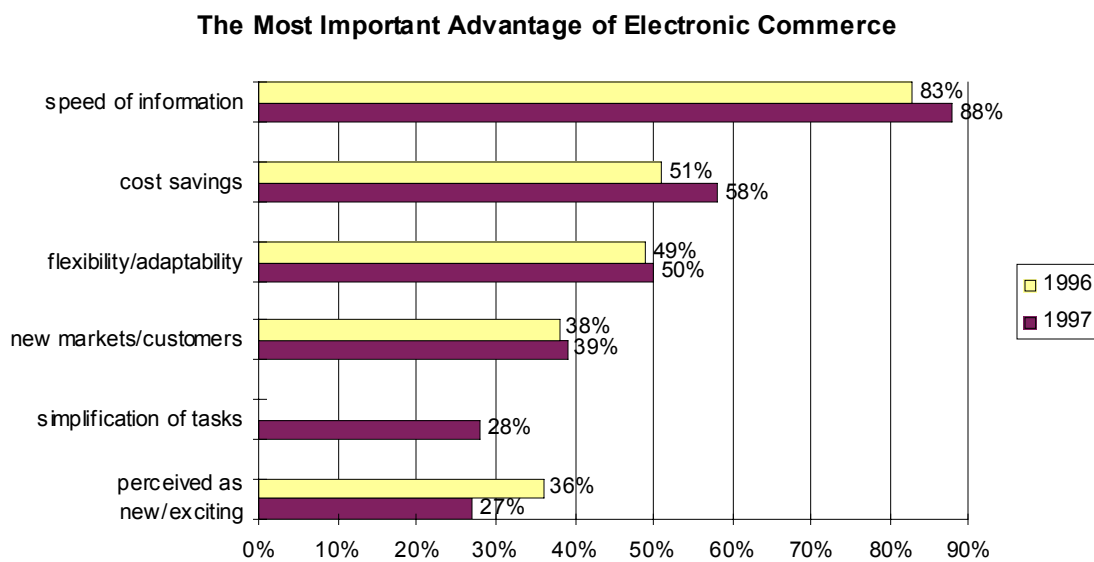


Exhibit 4: Reported Advantages of EC Source: KPMG Consulting

As evidenced in the responses above, companies across industry lines are increasingly interested in integrating EC. This is particularly true when companies are concerned with information speed, cost savings and flexibility. Between 50 percent and 88 percent of the respondents indicated that these are critical EC benefits. It also appears that access to new markets and access to new customers is perceived as increasing in importance over the one year time period. The implication for OEMs is clear: EC is gaining the attention of companies in most industries and the advantages brought about in speed, cost savings and flexibility are considered to be most important. For EMI OEMs that face increased supply chain management issues, a strong focus on EC appears to be appropriate.

Perhaps the most significant characteristic of the OEM market is its continual outsourcing, co-sourcing and partnering with others in the supply chain to produce the final product. This outsourcing practice enables the OEMs to be flexible in meeting

customers' changing needs. It also reduces time to market, facilitates greater focus on OEMs' core strengths, and reduces the need to build and own capital-intensive production facilities. Partnerships with outside suppliers have become more pervasive recently and are critical to the industry's continued innovation, price reduction, quality improvement and time to market. OEM outsourcing creates partnerships with EMS providers or contract manufacturers and is discussed in greater detail in the next section.

### 2.1.2 EMS Providers or Contract Manufacturers

Perhaps the fastest growing sector in the supply chain, electronics manufacturing service (EMS) providers (including contract manufacturers CMs) build printed circuit board products faster, cheaper and more efficiently than OEMs. These companies also have the resources to maintain component sourcing from numerous high quality suppliers. Subsequently, OEMs have less inventory carrying requirements, can provide far more flexibility to meet customers' changing demands, have fewer orders to process and fewer infrastructure investments to make. Effectively, the OEMs have transformed into organizations responsible for engineering, marketing and management (see Exhibit 5 below). This focus on designing, selling and managing suppliers is a model that can promote core competencies, reduce costs, improve decision-making, and improve flexibility. These are the same reasons other industries and leading companies have adopted the same model (e.g., Nike in apparel).

During the past several years, the role of the EMS providers has become more sophisticated moving into every area of the industry including design, manufacturing, sourcing, procurement, assembly and packaging. Prior to this development, OEMs were more vertically integrated and relied on extensive internal capabilities to meet production requirements.

The problems with this extensive vertical integration were threefold. First, OEMs had to make large investments of capital. Second, these investments were often in processes that did not add value to customers. And third, the OEMs had to focus management attention on these processes which diverted attention from more value-adding activities. These problems culminated in OEMs having large, inflexible infrastructures and further removed the OEMs from the customer focus necessary to promote flexibility in the fast changing market. OEMs recognized these problems and began outsourcing to EMS providers. The OEMs then were able to invest capital where it provided higher returns and added value directly to customers.

This evolution of supply chain relationships in the EMS and EMS provider industry is illustrated in by three phases depicted in Exhibit 5 below. With the push of more work onto the supplier base, OEMs are becoming increasingly dependent on EC to ensure the proper exchange of information between all partners.

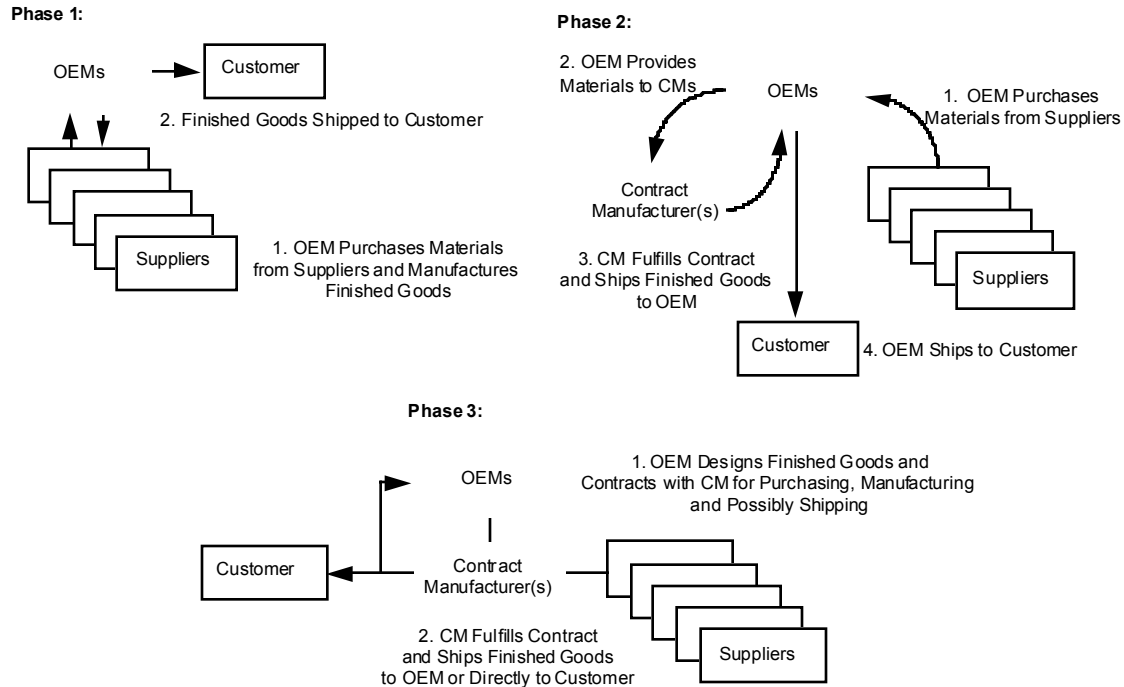


Exhibit 5: Evolution of Relationships Between OEMs and EMS/CMs

Phase 1 shows an industry where the OEMs are fairly insular. They assume responsibility for practically all aspects of design, engineering, product development, purchasing, manufacturing, quality assurance, marketing, sales and shipping. Interactions between the OEMs and other companies were limited to those suppliers located outside the vertically integrated OEMs. Such companies were typically suppliers of materials and services that the OEM could not economically produce internally. Limited interactions required only limited electronic exchange of information.

Phase 2 shows the migration from the inward-focused OEMs to a scenario where the OEMs recognized the benefits associated with utilizing contract manufacturers. These benefits included reduced OEM capital investments in plant equipment and capacity, an ability to force some quality assurance onto vendors, a reduced need to maintain fully utilized production facilities, and the ability to more precisely match production to demand. Phase 2 illustrates the scenario where the OEMs still maintained full control of design, engineering and purchasing. Nonetheless, an increased reliance on contract manufacturers necessitated greater interaction between OEMs and business partners which was facilitated in part by the emergence of e-mail, EDI and other forms of EC in facilitating communication and other inter-company transactions.

Phase 3 illustrates an evolution that is common in other industries outside of electronics (e.g., fashion, construction, footwear and aerospace). In this phase, the OEMs concentrate their resources on core competencies that may include design and engineering, marketing, sales and product/project management. In fact, some of these core

competencies (e.g., such as design and engineering) may also be outsourced to the EMS provider. Under this scenario, EMS providers are responsible for many of the activities that were the exclusive domain of the OEMs in Phase 1. This scenario provides many advantages to the OEMs including a further reduction of fixed costs, a greater degree of flexibility and the potential for improved quality. But this scenario also requires that the OEMs have more thorough interaction among business partners which stimulates a need for increased EC use to facilitate transactions. Useful EC for this evolved state of the industry includes intranets for operating divisions within the OEM such as design, engineering, marketing, sales and shipping. It also includes extranets for business partners to collaborate on designs and product development efforts, share information regarding technical specifications and pricing, and provide data on quality (e.g., defects per thousand). This scenario may also include EDI to exchange purchase orders, bills of lading, estimates or quotes, invoices and other forms between partners' systems.

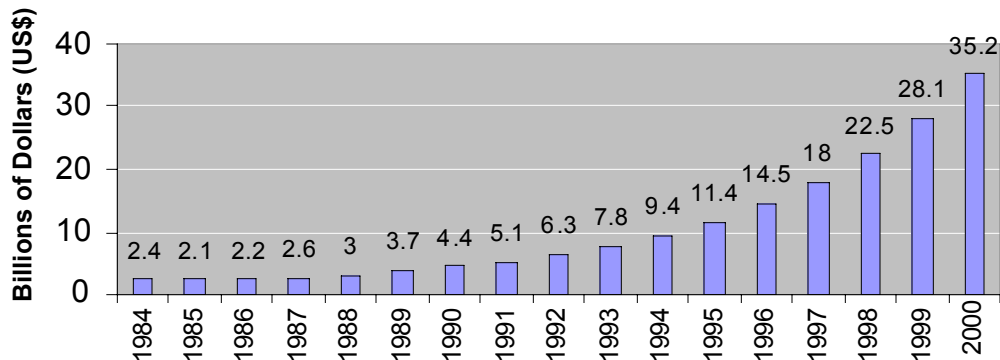
OEMs will typically avoid deep participation into the supply chain (e.g., working with suppliers three levels upstream). When dealing with EMS providers, an OEM may become involved with a supplier if a problem rises (e.g., quality or delivery). As mentioned above, OEMs are increasingly making EMS providers responsible for supplier management. This often occurs because the OEMs do not want the distraction and management burden associated with activities that can be accomplished by efficient EMS providers. This is particularly true when an OEM would have to deal with several hundred suppliers. When EMS providers have problems getting products out because of supplier issues, they may then turn to the OEMs for assistance, but generally the market mechanisms are in place to replace a poor performer (in the long run) or use the threat of supplier replacement (in the short run). When an OEM is committed to a product design change, it may become involved more with suppliers to ensure that they are in step with the required changes. Simply from a "partner management" perspective, the OEMs will get involved only when necessary.

With EMS providers taking on more of the OEMs' workload, the use of EC for purchasing becomes critical. Many EMS providers are executing this work with high margins. In order to continue this success they are striving to reduce the amount of inventory in their systems to meet OEMs' production requirements. They are also sourcing materials as cheaply and efficiently as possible. This requires closer purchasing links with suppliers and faster order fulfillment. These needs can be addressed through increased use of the Internet for purchasing. Sixty-one percent of the respondents to the KPMG surveys mentioned above perceive the Internet to be a cost-effective way to conduct purchasing activities.

The global market for EMS has grown at an unprecedented rate over the past 13 years. Forecasts for 1998 through 2000 predict a greater than 20% growth rate projected for each year as shown in Exhibit 6 below. This growth is a direct result of EMS providers providing excellent service in a profitable manner and facilitating fundamental changes to

the OEMs' business models. Nonetheless, some OEMs are not letting go of manufacturing and other product-focused activities. Such companies wish to retain manufacturing, purchasing and distribution capabilities so that they can internally control quality, ensure that confidential designs are not jeopardized, and maintain production capacity in the event of a surge requirement that the EMS providers cannot accommodate.

### History & Forecast of the Market for Electronic Manufacturing Services



Source: 1997 IPC Market Analysis

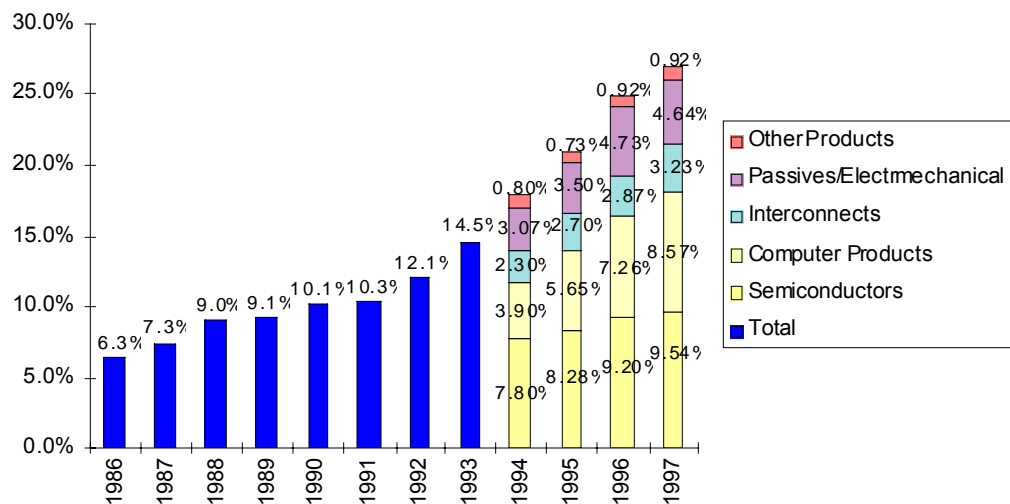
Exhibit 6

#### 2.1.3 Component and Semiconductor Manufacturers

Electronic components and semiconductor devices represent the fundamental building blocks of the electronics industry supply chain. This segment includes printed circuit boards, semiconductors and related devices, capacitors, resistors, and transformers.<sup>15</sup> Products are generally produced in large volumes with wide ranging types and sizes. Production must be fast and flexible to keep up with changing trends, technologies and growing downstream customer demands.

Component and semiconductor manufacturers face enormous pressures and critical issues in today's marketplace to remain competitive. These include maintaining short product life cycles, constant demands to decrease time to market of new products, capacity constraints, managing R&D and capital investment, and the constant challenge to gain or maintain market share. Growth of the components/semiconductor market is shown in Exhibit 7 below.

<sup>15</sup> Detailed information regarding each of these end products is beyond the scope of this report.



Source: EE Times Exhibit 7: Component and Semiconductor Manufacturing

As illustrated above, the growth in this market is consistent and is expected to continue in for the next five to ten years. As greater demands are placed on the suppliers in this sector, improved inter-company communication will be necessary. This will be facilitated largely by EC.

#### 2.1.4 Distribution

Distributors play a key role throughout the EMI supply chain offering OEMs, EMS providers, and customers one stop shopping for components and other product needs. Distributors provide customers with access to a wide variety of products for customers who can benefit from an increased selection without having to manage a great number of vendor relationships themselves.

Distributors are currently going through a period of increased globalization and expanded growth through acquisitions. As with many other segments of the supply chain, larger tier are continuing to grow and rankings of the top 50 distributors changes regularly.

This highly competitive segment of the supply chain demands that its members support global operations. It also requires that they constantly seek innovative ways to expedite delivery and maintain high levels of quality for delivered components. Because distributors face extremely short delivery times from customers, they often regularly maintain high levels of inventory to act as a buffer for peak demands. This is a model of JIT that only reduces inventory at the downstream customer, but does nothing to lower total costs of finished goods.

True JIT requires that all members of a supply chain deliver JIT to each member of the value chain. This means that no company creates large buffers of inventory for surge requirements, but rather each company has complete access to real time information



regarding production schedules and materials requirements from the entire supply chain originating with the OEM. This can be accomplished only through the effective use of EC by all companies in the chain. Other issues beyond the scope of this research include electronic catalogues and just in time (JIT) inventory management. However, there are some tools that the industry is looking at to improve inventory levels. From the point of view of the EMS provider, these tools include vendor managed inventory (VMI), point of use replenishment, better forecasting techniques (EDI has a transaction called the 830 Forecast that can promote reduced inventories), on-site suppliers, and innovative partnership agreements. These are some of the potential solutions in the distribution part of the industry that have been evaluated and in some cases adopted.

### 2.1.5 Service Providers

The role of service providers in the EMI is to ensure that down time for customers' equipment is minimized. For service providers supporting the electronics industry, fast response and repair times are critical to customer operations. Service providers' operations are usually backed up by a series of service centers supported by sophisticated logistics systems and software. Other critical success factors for this sector include highly trained staffs, high inventories of spare components to replace defective equipment, and quick access to localized service areas.

This highly competitive sector of the supply chain relies solely on the ability to service the end customers. The fast paced nature of the electronics business also benefits from organized supply chains, good communication tools, and the use of standard components and sub-assemblies wherever possible.

EMI service providers will increasingly adopt technology focused on automating customer communications. EMI machinery that automatically notifies service providers when maintenance is needed is feasible, but not necessary. Routine maintenance of plant equipment is already computerized where better service providers utilize programs to plan and record periodic maintenance.

### **3.0 National vs. International Industry and Technology Pressures**

Each segment of the supply chain faces unique pressures that are driven both by domestic and international market forces. A review of some of the industry and technology pressures is presented in this section.

Contract manufacturers have been the fastest growing sector of the EMI. The successful companies are continuing to expand through acquisitions at the expense of the smaller organizations. As more business is outsourced from the OEMs, the role of the EMS provider has expanded into new territories. Some of these territories include global sourcing and global vendor management. With this expansion, come pressures including the necessity to integrate directly with customer design and production demands, integration of material requirements planning (MRP), and the integration of enterprise resource planning (ERP) systems with OEM demands worldwide.

With the technology available today, it is unlikely that the supply chain can be dominated by one ERP system. EMS providers and their suppliers require the technology and systems to accept MRP, sales and engineering data from OEMs and must be able to process this information in-house as quickly as possible. It is not so much a question of which ERP system will dominate the industry, but how fast, efficient, and accurate can information be passed to suppliers. The answer is forming partnerships with trading partners to make sure that everyone in the chain understands how the system works and understands how data is processed. One way that EMS providers help with this process is they may have a full time representative at the customer site. Under this scenario, the representative gains a better understanding of the customer's business and can more effectively or directly deal with the information generated by MRP and/or any information generated by the ERP system.

Distributors face similar pressures to provide the highest levels of customer service in this extremely competitive part of the supply chain. Distributors provide variety in all available components with a reduced cycle time. Due to their high margins, they are expected to carry sufficient levels of inventory of any product and drop ship immediately upon order placement. They are also forced to participate in globalization or lose competitive advantage. Sourcing globally using the Internet and migrating to even tighter networks like intranets can facilitate this requirement.

Component and semiconductor manufacturers also face a demanding market affected by fluctuations in global demand and pricing, shrinking margins, and fierce global competition. Time to market with technologically advanced products is vital along with the ability to alter designs for product market developments. The computer industry has traditionally provided the largest customer base for this segment and although it remains

strong, other industries have recently facilitated growth of support for component and semiconductor manufacturers. Some of these growing sectors include household appliances, games, toys and even new technologies within the printing press industry. All of these sectors require companies to source globally and deliver anywhere in the world. Again, this operational requirement can be facilitated through closer links to the supply chain through EC.

Producers of printed circuit boards face serious market and technological pressures as well. Although the U.S. is among the top suppliers of printed circuit boards in the world, there are constant pressures to remain competitive in the global market. Many foreign manufacturers are reducing costs by offloading production into newly developing countries. These lower cost boards will eventually make their way into the domestic market forcing domestic manufacturers to reduce costs through operational efficiency, reduced margins or improved purchasing. Many of these improvements can be facilitated by EC.

Secondary sources of information used for this report revealed some general trends regarding the distinction between domestic and international technological pressures. For example, there is evidence to suggest that Western EMI supply chain companies (domestic and European markets in particular) are more leading edge in using Web-based Internet transactions and various other forms of EC. Although domestic customers encourage vendors to use the Internet and other EC for transactions, the gap between domestic usage and international usage continues to grow. In one example, the International Data Corporation predicts that for 1998 the amount of EC business estimated for Hong Kong will be approximately \$37.2M, compared to the \$21B conducted in the U.S.<sup>16</sup>

Evidence also suggests that the technology used in the manufacturing of PCBs, power systems and microelectronics are also more advanced in the highly technical and competitive U.S. manufacturing markets. Products may be built faster and cheaper in global operations with far different quality standards, however these products still find their way into the general market. The result is significant fluctuations in global pricing and demand. Because PCB assembly is a relatively complex process, this is more common to specific areas of electronics such as the memory market. Consistent reductions in the price of memory in recent years may be evidence of this trend.

Perhaps the most important technological pressure is also the most fundamental. This pressure is the relatively low capabilities that companies have to address EC adoption challenges and opportunities. Companies in the EMI supply chain may not be ahead of companies in other industries in adopting EC. In fact, as mentioned above, many companies within the EMI may lag behind other industries and should be moving faster.

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<sup>16</sup> 1998 South China Post Ltd. August 4, 1998

Those that are adopting are doing so as the result of this industry's need to communicate throughout the supply chain and to be extremely responsive to customer delivery requirements. Such seamless integration among trading partners necessitates the use of technology. Nonetheless, some industry participants are not well positioned to capitalize on EC. Without proper resources, companies will not be able to compete effectively and may ultimately lose market share.

In a recent KPMG study, we learned that the majority of respondents believe they possess the right resources to address EC. Nonetheless, a large number of the companies indicated that they lack the resources to effectively adopt EC. This is alarming because the companies studied by KPMG are larger organizations possessing the financial resources necessary to hire talented employees or engage consultants to address critical issues. A possible conclusion of this finding is that smaller companies, possessing far fewer financial resources, are even less capable of integrating a robust EC component to their business. Alternatively, it could mean that even though smaller companies lack the financial resources to adopt EC, their requirements are not as great as the larger companies. This would be true assuming that a preponderance of the effort required to successfully adopt EC is focused on cultural issues, redesign of processes across the enterprise, and rethinking strategic models that have worked for decades.

Another industry and technology-related pressure is familiar to the EMI and virtually every other U.S. industry. This is the pressure to hire talented, experienced and dedicated human resources. Attracting qualified engineers, programmers, technicians, machinists, designers, marketers, systems integrators and managers is challenging to even the most well respected companies. This is yet another opportunity for companies in the EMI to increasingly utilize the Internet. Many are using their Web sites to post job listings, to solicit resumes electronically (often to be scanned for key words and phrases at the company), and to convey information that job seekers find useful in selecting an employer. It is reasonable to assume that given the scarcity of professional systems integrators, systems may come to market that have a degree of automated integration.

## 4.0 Near Term and Anticipated Trends Within the EMI

Both global and domestic markets will continue to be driven by the need to create an integrated relationship between suppliers of printed circuit material, PCB equipment, PCB manufacturers and OEMs. This includes the continued general trends towards increased speed, flexibility, and reductions in cost across the entire supply chain.

### 4.1 Current and Future Uses of the Internet

With the Internet spreading its influence across the globe, it is just a matter of time before it seriously infiltrates the business-to-business sector. In an effort to eliminate inefficiencies, reduce inventories, respond to customer changes, and lower manufacturing costs, companies are looking to integrate and better manage their supply chains. The Internet can be the tool to provide the solutions with benefits such as reduced costs, increased security, easy access, and the ability to provide an interface with a very large trading community.

As well as trying to make sales over the Internet there is evidence to suggest companies are trying to use the Internet for a variety of traditional business transactions. Companies realize that the Internet can help with improving basic business processes and perhaps provide more cost-effective methods to access less defined business channels. The following exhibit shows the responses of EMS providers when asked to indicate the percent of documentation they would like to complete over the Internet. This indicates the desire of professionals in the EMS provider industry to use the Internet for traditional business to business documentation.

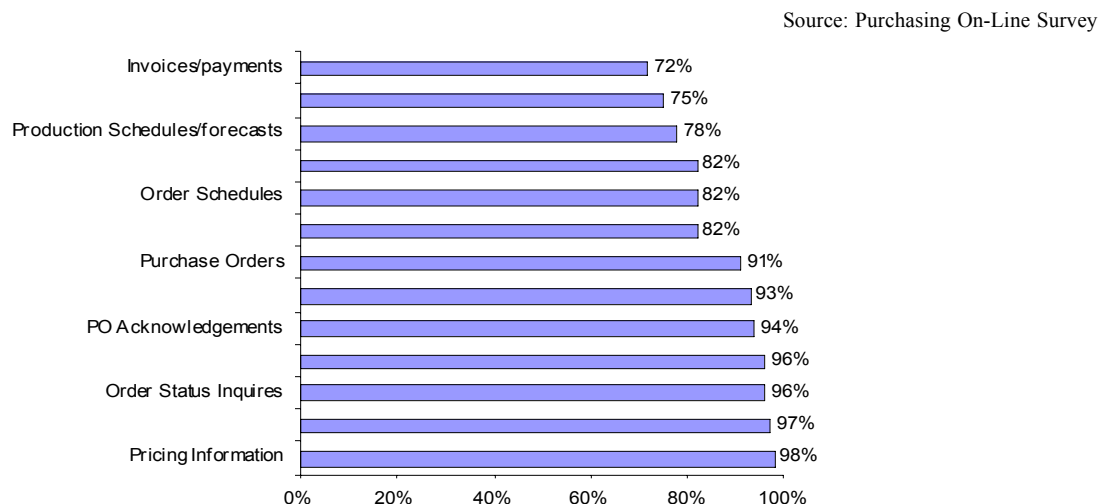
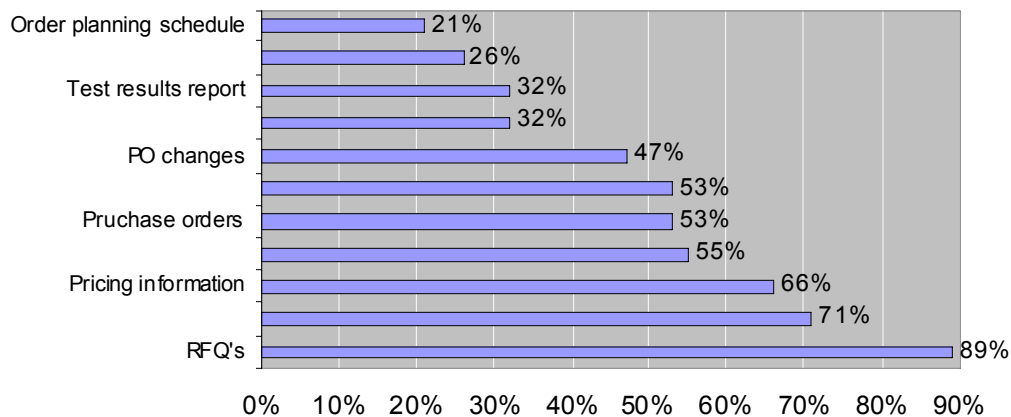


Exhibit 8: EMS Internet Usage

In a similar, broad based business survey, purchasing professionals were asked what areas of the business would they like to see expanded to the Internet. Many of the business transactions listed in the exhibit below are those traditionally handled by EDI. This is evidence that organizations are willing to invest in other EC media to handle their operations.

**Q: Are you interested in using the Internet for purchasing transactions?**



Source: Purchasing Magazine Survey

Exhibit 9: Internet Purchasing Breakdown

## 4.2 Mergers and Acquisitions

Throughout the supply chain mergers and acquisitions play an important role in determining the shape and business processes within the EMI. Within each segment of the industry, larger corporations continue to grow at the expense of smaller entities in an effort to fight shrinking margins. This has been a consistent trend over the past few years mostly in the distribution and EMS provider sectors. Ultimately, as these companies grow larger, they also take on more of the responsibility for setting technology standards for the entire group.

## 4.3 Outsourcing of Manufacturing Services

As described in detail above, there are numerous reasons for the widespread outsourcing of manufacturing services by OEMs. Through outsourcing, OEMs can limit non-value added infrastructure, promote flexibility to meet customer requirements, choose suppliers with high degrees of specialization and quality products, focus on core competencies and get closer to the customer. The outsourcing agenda will continue in the EMI as OEMs recognize even more opportunities to limit investments and capitalize on the abilities of specialists. As mentioned above, the trend is for increased specialization of the supplier

base (particularly at the EMS provider level). The trend is for EMS providers to offer every possible service to OEMs.

This trend towards outsourcing enables OEMs to focus on marketing and sales activities. The added responsibilities of assuming the OEMs' outsourcing challenges means that suppliers must become more sophisticated and must challenge their traditional roles within the supply chain. This means that the suppliers need to work into the virtual integration model that provides seamless integration between all members of the supply chain.

Many companies are adopting enterprise systems that replace existing legacy systems in an organization. These enterprise systems are making it possible for companies to seamlessly integrate information from formerly disparate business units and stand-alone information systems. This integration enables companies to make information available to upstream suppliers and downstream customers where necessary. Some industries, such as the petrochemicals industry, are using enterprise systems to facilitate an improved flow of information throughout the supply chain. This has been so widely adopted in certain industries that the enterprise systems have become "de facto operating standards".<sup>17</sup> The trend to adopting enterprise systems to facilitate the organization, management and distribution of information has made it difficult for companies in these industries to survive without adopting the de facto operating standards presented by the enterprise systems.

As OEMs continue to outsource manufacturing and other critical activities to suppliers in the EMI, the notion of enterprise systems becoming de facto standards is important to recognize. Already the SAP R/3 client server (and to a lesser extent the SAP R/2 mainframe) enterprise system is being adopted by most companies in the personal computer, semiconductor and consumer goods industries.<sup>18</sup> As these companies adopt this very specific package system solution, the implication for suppliers is clear: they must be able to participate in the flow of information mandated by these companies' systems and business demands.

#### **4.4 Globalization**

As EMS providers, distributors, and component manufacturers continue to expand their operations, the result will be the increased globalization of companies within the EMI. Companies are currently expanding operations throughout the globe to take advantage of commodity pricing, lower production costs, and to provide full access to a variety of services for customers. Globalization will be facilitated by EC, which will serve to reduce

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<sup>17</sup> Putting the Enterprise Into The Enterprise System, p. 126, Harvard Business Review, July-August 1998, Volume 76, Number 4

<sup>18</sup> IBID

the perceptible distance between partners by promoting collaboration, access to data and other valuable communication.

#### ***4.5 Shrinking Product Life Cycles***

One of the most challenging aspects for any segment of the EMI supply chain is the ability to keep pace with the constant changes in new technologies. The only thing consistent in the electronics industry is that the market will continually change. To cope with this constant change, companies must always be one step ahead of the competition. They must also be in line with the customer -- both the customer immediately downstream and the end user. New product development and design will continue to require the best resources available and the shortest time to market. Again, EC will likely play a prominent role in supporting these initiatives.



## **5.0 Analysis and Observations**

### **5.1 *EC Technology and Emerging EC Practices***

EC, as discussed in the introduction, is simply the exchange of electronic information between parties. Within the EMI there are two areas that draw immediate attention as strong candidates for EC. The first is the purchasing cycle. The second is the design cycle. Both of these areas have solutions in place that rely on either historical standards (EDI) or proprietary solutions (CAD/CAM interface).

Both purchasing and design complexities have evolved from the supply chain's historical development as discussed in the industry overview. This results in increasing pressures due to the continuing demand by OEMs to further lengthen and narrow the supply chain as described below.

When the supply chain lengthens, additional pressure is placed on the cycle in total because companies can recognize the full return on their investment in electronic commerce only if all parties with which they interact are able to automatically receive and transmit data within the same standard.

The narrowing of the supply chain represents a desire to deal with a limited number of vendors rather than compete orders across a wide range of companies. This increases the costs associated with dealing with non-integrated providers. Many OEMs are actively pursuing a purchasing strategy of having the fewest suppliers possible to meet their needs. In effect, OEMs are dedicated to outsource as much as they can, but wish to limit this outsourcing to as few partners as possible. Some OEMs report that despite this intent, the supply chain often experiences growth spurts that results in more complex supplier relationships. When this occurs, the OEMs actively go through the ranks and eliminate suppliers that are not providing the best products. This does not imply that bidding and negotiating are low priority activities in terms of EC services. These activities are the more challenging parts of the purchasing process to bring into the EC world. As part of the process and beyond EC, customers also consider service, trust, partnerships, inventory handling, and "one-stop" shopping in choosing suppliers.

In the EMI, some suppliers that meet all an OEM's needs (or the needs of the purchasing EMS provider) in one year may not be acceptable in the next. Other suppliers consistently provide quality products and innovation to remain partners in the long term. In order to strengthen relationships with customers in the EMI under these scenarios, it is important for upstream suppliers to effectively utilize EC in a manner that supports the entire value chain. This effective use of EC will not only put a supplier company closer to the customer, it will provide the supplier with more accurate and timely information that supports by the purchasing and design cycles.

Another issue in the EMI is the increased attention on moving inventory through the value chain faster. In the past, some OEMs focused on stockpiles of inventory that provided these companies with buffers to meet fluctuating downstream demand. OEMs are more proactively turning towards their suppliers to help minimize the inventory content of finished goods. This gives the OEMs an opportunity to capitalize on reductions in component and material costs, minimizes the chance of OEMs getting stuck with obsolete or second rate technologies, and drastically reduces inventory carrying costs. These trends will drive large manufactures and distributors away from those suppliers that are not electronically enabled and capable of becoming virtually integrated.

## **5.2 Purchasing Cycle**

The EMI is facing the same purchasing cycle issues that challenge many other industries. These issues center on finding a cost-effective standard for the transmission of purchasing information throughout the supply chain. To date, EDI has been the standard by which organizations in the EMI and other industries exchange this information. However, both the human and capital costs for implementing EDI can be sizable.<sup>19</sup>

Industries are looking to the Internet to provide a catalyst for moving towards an integrated purchasing model that can be used by all members of a supply chain. Such a model would promote what some in the EMI and other industries with complex supply chains are calling virtually integrated organizations.<sup>20</sup> This term is used to describe OEMs that are able to closely link suppliers in a value chain in a manner that provides the entire chain with the operational advantages of a vertically integrated company. Additionally, it can enable the value chain to include the customer that promotes superior market feedback to the OEM. The OEM uses this feedback to improve forecasting and planning which is shared throughout the supply chain. In addition to including the customer and others that provide material and finished goods, this model also includes the distribution agents as integrated players.

With the increased demand for JIT along the entire supply chain, the transportation and distribution providers are critical to maintaining high velocity throughout the industry. These companies increasingly rely on the same information that helps the manufacturers and others throughout the supply chain plan production. OEMs and EMS providers regularly require distribution companies to coordinate extremely detailed pick ups and

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<sup>19</sup> Given the time constraints for this effort, precise costs associated with EDI are not provided. At a high level, the costs associated with EDI come in the form of selecting, purchasing and integrating hardware and software; employing the technical staffing; setting up suppliers and customers; developing relationships; and management. This is especially true for some smaller organizations that are being forced to use the technology. It is a *sizable* investment, which is why we mention emerging and potentially more popular forms of communication for the future (e.g., the Internet as an alternative).

<sup>20</sup> Michael Dell of Dell Computer Company describing his company's ability to blur the traditional boundaries between manufacturers, suppliers and customers in a supply chain through the use of EC.

deliveries around the world in order to optimize production and minimize cycle time. This is what enables companies to maintain the absolute minimum levels of inventory necessary to meet production schedules. In many cases, this inventory is only a few hours worth. This is a big difference from the more typical days, weeks or months worth of inventory, which was not uncommon only a few years ago.

Thus, all companies in the supply chain (or virtually integrated company) are in a position to share information on a real time basis. Information sharing includes the exchange of designs, specifications, forecasts and other information that speeds up the product development cycle and the sales cycle. This information sharing results in the ability for everyone to plan production better and to comply with the increased requirement of JIT delivery throughout the chain.<sup>21</sup>

The advantages of this model for the OEM include an opportunity to become closer to customers, form stronger relationships with suppliers, narrow the supplier base to only the best companies, focus on core competencies, and eliminate the need for the enormous investments of more traditionally vertically integrated companies.

With the more closely aligned virtually integrated companies comes a value chain that delivers higher quality, lower cost and lower variability products. It also provides these products when the next processing company needs them.

One final point on the purchasing cycle. It is expected that agent software may soon be available that could handle the task of finding quotes from suppliers around the world. This software may act like a high speed purchasing agent that works twenty-four hours a day at finding sources for materials and services that meet price, quality and delivery requirements.

### **5.3 Standards**

EMI companies are already active in placing themselves on the Internet along all stages of the supply chain. As described above in the EC adoption model, companies in the EMI go through each stage as follows:

- Stage One: Companies have the ability to send and receive e-mail and their web sites have static information including a purchasing phone number, policies and procedures and order forms.
- Stage Two: Inventory availability and PO status are available on a company's web site.<sup>22</sup>

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<sup>21</sup> JIT throughout the chain implies JIT deliveries to each company along the supply chain rather than having a situation where suppliers stockpile finished goods and materials for delivery when required thus passing these costs onto the OEMs in the end.

<sup>22</sup> Neither stage one or two requires the creation of standards, as all the information available would be accessible via a web browser and controlled by the standards of the WWW.

- Stage Three: Large companies are selecting purchasing software. Traditionally in this stage there is limited electronic two-way communication between the purchaser and the supplier, and little or no communication between the supplier and their supply chain. Therefore the industry leverage that should be created by standards does not exist. Note: if there is no stage four present in the industry, the creation of standards at stage three can be used to move industries to stage four.
- Stage Four: Full interoperability not only within an organizations system but also across organizations

A company in the EMI can achieve stage four without the existence of standards however the costs associated with servicing that client by their partners will have to be weighed against the revenue that partner generates. Without the creation of standards at this stage industry participants downstream from the OEMs are at a disadvantage because they have to support multiple communication standards. However, the emergence of standards at this point allows companies to effortlessly move between both suppliers and purchasers without fear of having to modify or change their IT systems.

There are traditionally three ways that standards effectively emerge within an industry:

1. A Government agency mandates a set of standards for industry.
2. An independent or industry-sponsored organization builds consensus for standards.
3. Large organizations determine an interface and determine standards through their market influence.

Currently the Open Buying on the Internet (OBI) Consortium is taking the lead on setting standards for execution. This is a non-profit organization dedicated to developing open standards for business-to-business Internet commerce. The OBI Consortium is an independent collaborative managed by CommerceNet. Membership in the consortium is open to buying and selling organizations, technology providers, financial institutions, and other interested parties on an annual fee basis. The consortium provides a forum for standards development, education, and compliance certification. The OBI standard provides access to easy-to-use, open, standards-based Internet purchasing solutions for the procurement of high-volume, low-dollar indirect goods and services. For a list of current members and more information, the OBI Consortium is located on the web at [www.openbuy.org](http://www.openbuy.org).

There are two important conclusions from this observation. One, the recognition by industry (all industries) that a standard for the exchange of purchasing information is a valuable endeavor. Two, in order for the large number of SMEs in the EMI to continue supplying the industry, the information solution should not consume a significant amount of capital (monetary or human).

NIST should not take a primary role in the organization of the standards for the OBI, but should consider a role in seeing that standards (and the products developing around the standards) are maturing to a point where scaleable solutions are available for companies along the entire supply chain. This includes the smaller companies that are critical to the viability of the EMI.

#### **5.4 Focus on SMEs**

Small and mid-size enterprises (SMEs) in the US microelectronics industry represent over 97% of the companies in the electronics industry.<sup>23</sup> This preponderance of SMEs implies opportunities for NIST MEP to assist these companies in remaining competitive and forming reliable electronic links to OEMs.

Adopting and meaningfully applying EC technologies may be a challenge for some SMEs. First, not all SMEs will immediately recognize the benefits of making the investment in equipment, software and time. In this industry, it is likely that OEMs will force the adoption of EC to companies wishing to remain competitive. It is also possible that the adoption of EC by competitors could effectively force SMEs that do not use EC out of a competitive position with key customers. A growing number of OEMs and other key customers in this industry are establishing requirements for a full range of EC participation for supply chain members. Non-compliance by companies can effectively become a permanent barrier to entry or a reason to be cut from a vendor list.

Second, some SMEs will be reluctant to form close alliances with other vendors and in some cases, with customers. This will be true where SMEs believe that forming such EC-based relationships will introduce the possibility of a compromise of sensitive information. SMEs are typically extremely private about their businesses, processes, finances and other aspects of their operations. EC can be an intimidating factor for these companies.

Third, SMEs may recognize that the introduction of EC may necessitate the redesign of business processes to optimize the effectiveness of the investment. This can be costly and may require management attention that is often already highly fragmented. Some SMEs will be reluctant to adopt EC because they cannot devote the resources to optimally design business processes to capitalize on EC.

Fourth, some SMEs will be intimidated by the rapid technology evolution of EC and will opt to sit on the sidelines until the industry slows down. This is the case where the SMEs have a concern relative to evolving and competing standards, uncertainty regarding the direction of the various mediums of EC, and concern over the obsolescence of IT

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<sup>23</sup> US Department of Commerce

investments. Also, many industry pundits disagree as to the emerging “standard” applications that will facilitate EC, which further creates confusion. Such competing applications include payment software, wallets, coins and other software designed to facilitate transactions.

Fifth, there is a tremendous amount of uncertainty among SMEs and larger companies regarding the security of conducting transactions via EC (e.g., using the Internet to complete a purchase transaction). These concerns are heightened by stories of hackers, failing networks and the Y2K crisis which all portend security problems associated with Internet commerce.

Despite these challenges, SMEs are in an excellent position to adopt many variants of EC. First, SMEs enjoy the advantage of being more flexible than some larger companies. This flexibility translates into an ability to quickly adopt EC into business processes and to reengineer processes to optimally utilize EC. When SMEs are willing to make the investment in time and capital to develop new processes capable of supporting EC, they can typically complete this process faster and with a greater focus than larger companies. This explains why so many of the successful Internet-based businesses today are start-ups such as Amazon.Com. These start-ups are forcing their larger competitors to reengineer processes and rethink strategy in order to capitalize on various aspects of EC.

Another advantage that SMEs have relative to larger companies in adopting EC is that the former are more likely to condense the stages of maturity described above. Where a larger company may stretch out the experimentation and ad-hoc implementation stages to await detailed analytical studies about market penetration and business planning, an SME might move quickly from experimentation stage to integration without long delays for analysis, board approval and large-scale reengineering efforts.

Third, it is possible that by using the information gathered through effective EC use that SMEs can become better at developing new products that are more tailored to customers’ needs. Companies can also gain a better understanding of customer requirements and can optimize production forecasts based on this knowledge. Also, the use of this information that effectively puts a company closer to its customers will also enable the seller to handle administrative tasks in a manner that is faster and more accurate. Such tasks include shipping instructions, terms and conditions, addresses and other administrative information.

Finally, as mentioned above, it may actually be necessary for some SMEs to adopt EC practices if they intend on remaining viable business partners with key customers.

## **5.5 EDI vs. the Internet**

As electronic commerce continues to grow in popularity and usage, (expected such drastic numbers are leading segments in the supply chain to get ready for an EC

explosion. Traditional versions of EC such as EDI rely on electronic standards by which buyers and sellers exchanged orders, invoices and parts specification. All of this information transfer still required some human interface to manage the transaction sets. Although EDI can handle high volume and adheres to common standards, setting up a system is still expensive for SMEs. There are also different standards used internationally, which create further challenges.

Newer versions of EC like the Internet are truly machine-to-machine. These require little or no human intervention. It offers more opportunities for improved customer service, lower operating costs, additional advertising coverage, and a growing customer base. Some benefits the Internet offers versus traditional EDI systems include lower costs, the ability to handle numerous transactions globally, customization, and quite simply, everyone with a desktop has access to the medium.<sup>24</sup>

## **5.6 Design**

The evolution of OEMs away from the build aspect of product development has a direct implication on the product design. In some cases, OEMs have outsourced the design element to independent shops even further contributing to the lengthening of the supply chain. The design process has begun to be influenced by input of the EMS providers, which OEMs will outsource assembly as described in detail above. In turn, the EMS providers are pushing the design elements to the component manufactures for either change recommendations or endorsement.

The communication of the design prior to finalization has the potential to reduce product field failures, unavailability of key components and for the design to begin to be created with manufacturability in mind. In short, communication of the design can begin to limit bad design. Suppliers should be a part of the design process as far down the supply chain as possible. The greater the supplier's communication with the OEM the better. This will enable suppliers to incorporate any last minute changes to designs and lower the risk to manufacturing product defects. There is clearly a need for more efficient technical data exchange in the industry as implied above.

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<sup>24</sup> A discussion of XML/EDI may be beneficial to this section, but is beyond the scope of this effort.

## 6.0 Conclusions

The potential offered by EC is now being realized in the EMI and other industries. It is a way of doing business faster and more effectively. EC is a powerful means for improving communications, information gathering and trade between companies. As EC becomes more widespread, the need for companies to adopt new technologies and processes to gain competitive advantage is increased.

As described above, the major issues that concern companies focus not on the technical challenges of implementing EC, but rather on the more fundamental issues of integrating EC into business processes and strategies. This is a real concern for companies despite their increasing awareness of the potential benefits of EC.

The perception that money cannot be made through Internet transaction is being challenged by business models that rely extensively on transactions over the Internet. The Internet is forcing companies to re-think major aspects of the way they are organized. It also raises major strategic issues and is accelerating developments such as globalization, customer service and supply chain management. Markets are being transformed as barriers to entry are torn down.

A business case for adopting EC within the EMI supply chain includes much of the analysis above. Key points in business case development for EMI supply chain participants include the recognition that EC is facilitating access to new markets, bringing supply chains closer together and creating an environment of low cost, high velocity production. These results are mirror images of the characteristics of the EMI today. Additionally, as companies move more information from existing legacy systems into enterprise systems, the flow of information through a supply chain can be vastly improved. As mentioned above, this is contributing to other industries adopting certain enterprise systems as “de facto standards” .

A second point in developing a sound EC business case is the awareness that companies in the EMI are already adopting the technology and that to ignore this development will reduce market opportunities. This is particularly true where OEMs are consolidating supply chains and requiring the remaining participants to be electronically connected. This connection yields all of the advantages discussed above including increased speed, open communications, improved forecasting, reduced risks and other strategic advantages. Without these advantages, opportunities to participate will disappear.

A third element of the successful EMI business case includes the recognition that competitors may realize completely new opportunities through successful EC implementation. This implementation, while being potentially disruptive in the short



term, may lead to new business models that result in higher margins, lower costs and more revenue.

A fourth element of a persuasive business case includes a focus on the new processes that may be required to successfully implement EC. It must be understood that EC may necessitate redesigned processes to accommodate the technology and the new EC-based strategy. In addition to process redesign, it should be understood that a focus on the cultural issues will be required to effectively integrate EC on an enterprise-wide basis. This attention to process redesign and cultural issues will be reflected in an individual company's cost-benefit analysis included in the business case. The business case will justify the costs of completing these activities on the basis of the long term benefits accrued by a company that operates more efficiently internally and with partners.

A fifth element of a successful business case reflects the fact that the EC integration is driven from the top of the company rather than from a single division. Many companies at the early stages of adoption and maturity are leading EC from the IT department or the marketing department. Full-scale implementation will require that a decision be made to drive the adoption from the top of the organization. This needs to be considered in the business case.

A sixth element of the business case should demonstrate that with relatively low cost of reaching so many potential customers and suppliers, the Internet should become a central component of a company's EC strategy. The Internet is gaining in popularity in the consumer markets and it is becoming recognized as a valuable source of information in the business-to-business markets as well. This business-to-business adoption will continue to evolve as purchasing departments seek ways to improve speed and responsiveness to their organizations. The supply chain topics addressed above apply here and can be summarized by the concept that access to so many trading partners allows for greater choice, more competition and potentially reduced costs.

A final element of the business case should convey the fact that the use of the Internet as a central component of the company's EC strategy greatly reduces the barriers to entry that some companies face when leveraging core competencies to enter new markets.

In completing an effective business case, it is necessary to understand that even the best-managed companies may struggle when new technologies are introduced that render current investments in technologies obsolete. Having a plan to capitalize on the developments of EC as they apply to business-to-business transactions in the EMI can give small and large companies an advantage in dealing with the disruptive aspect of technology adoption. While less prepared companies are debating the consequences of alternative strategies, the prepared companies can get on with the process of adopting a mature model to carry out business in a completely new way. Reflected in a business

case, company boards should be quick to recognize the potential of an EC investment and competitive strategy for sustaining a long-term advantage in the EMI and other industries.